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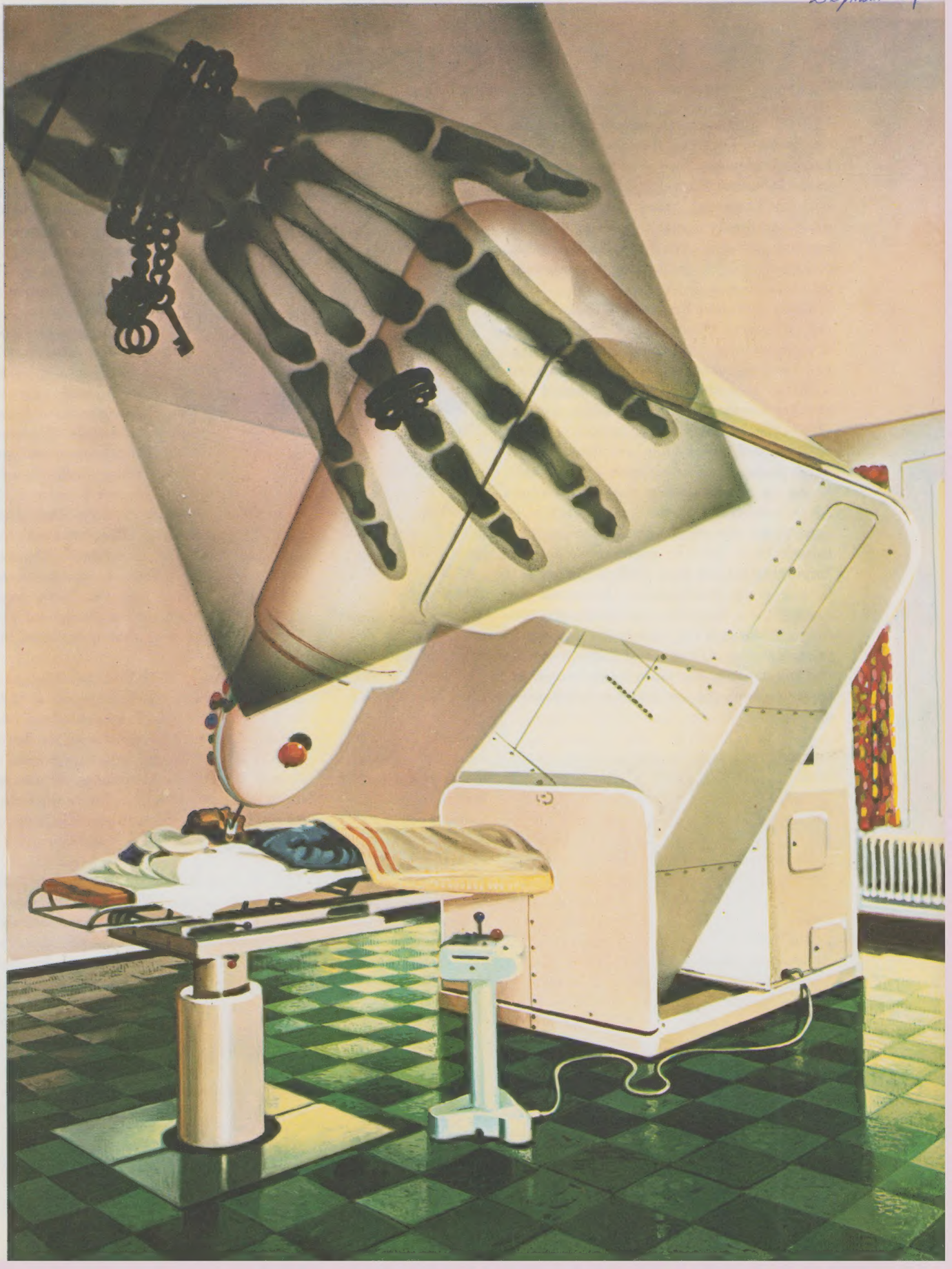

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X X-RAYS

THE professor was unusually late for dinner. Perhaps, thought his wife, he had forgotten the time. She sent a servant to the laboratory to remind him; but it was not until several hours later that the professor finally appeared. Even then he hurried through his food and quickly returned to the fascinating experiments on which he was at work.

That afternoon Professor Wilhelm Konrad Röntgen, Professor of Physics and Rector of the University of Würzburg, had been repeating some experiments with a little cathode-ray tube designed by another German physicist, Philipp Lenard (1862–1947). This tube, made of glass and about 9 inches long, was fitted with a small metal plate or *electrode* at each end. When an almost perfect vacuum had been created in the tube by a powerful vacuum pump and a voltage difference was applied to the electrodes, a stream of invisible rays, called *cathode rays*, left the negatively charged electrode or *cathode*. Impinging on the glass wall of the tube, they caused it to glow with a green fluorescence. One small part of the wall of the Lenard tube, however, was made of a thin piece of aluminium foil, and through this 'window' some of the cathode rays escaped to the exterior. If a sheet of paper covered with a thin coating of the salt barium platinocyanide were held in the beam of rays emerging from the window, the salt fluoresced, just like the walls of the tube.

Wilhelm Konrad Röntgen, the discoverer of X-rays

Having repeated Lenard's experiments to his satisfaction, Röntgen thought he would do them all over again with a windowless kind of cathode-ray tube designed by Johann Wilhelm Hittorf (1824–1914). He arranged his apparatus and switched on the power to the electrodes. Then, just as he was about to demonstrate that cathode rays did not escape from the windowless Hittorf tube, he noticed that a barium platinocyanide screen lying several feet away was fluorescing brightly. It seemed impossible! Nobody before had managed to obtain cathode rays *outside* a Hittorf tube, nor had anyone seen cathode rays travel so far. Something new, something mysterious, must surely be the cause of the strange fluorescence. Wilhelm Röntgen set out to discover what it was.

For several weeks the professor remained in his laboratory working away at his problem. He soon found that his newly discovered rays would penetrate paper, cardboard, and wood, and that, by using materials of increasing density, he could block more and more of the rays and thus cause dark shadows on the parts of the screen which they did not penetrate. He showed that metals, particularly lead, gave very dark shadows since they were almost impenetrable. He received quite a shock when he held a small lead disc above the screen and saw, for the first time, the shadows of the bones in his own hand. He found, too, that the rays would 'expose' a photographic plate, and that a permanent photographic record could be made of anything that was placed between the tube and the plate.

By the end of 1895 Wilhelm Röntgen felt that he had investigated his discovery sufficiently for it to be revealed to the world. In a brief paper which he submitted to the Würzburg Physico-Chemical Society he described his discovery of the mysterious new rays and the experiments which he had performed with them. With great astuteness, he also indicated his belief that these rays came from the glass wall of the tube when it was struck by the rays from the cathode. His paper was accepted, published, and acclaimed within a few days.

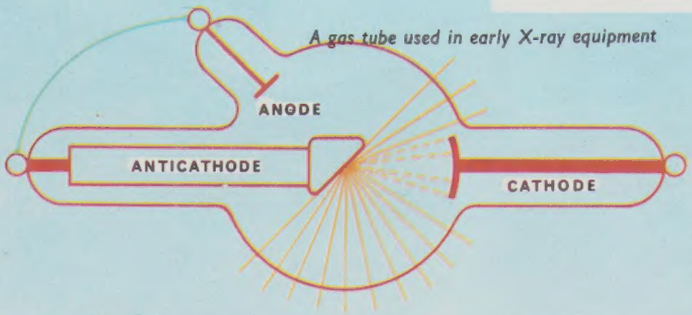
The diagrams and illustrations of X-ray equipment in this article are based on material contained in **X-rays** by **W. E. Schall** (publishers: John Wright)

The windowless Hittorf tube

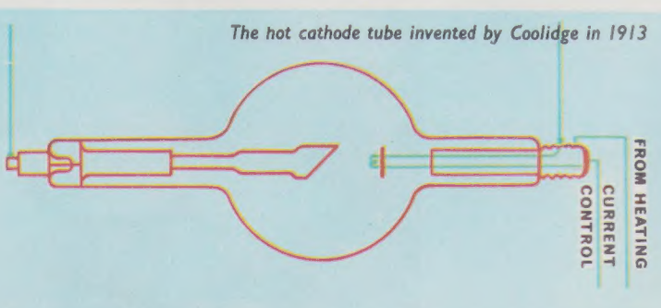
The X-ray tube

The applications of Röntgen's new rays, or X-rays as they soon came to be called, were so immediately apparent, particularly in diagnostic medicine, that people all over the world began to build and use X-ray equipment. In those early days the tubes which were used were known as *gas tubes*, for their successful

A gas tube used in early X-ray equipment



The hot cathode tube invented by Coolidge in 1913



SHELLEY

FOR many people today Shelley is the poet of winds and clouds and the sky, an idealist who breathed into poetry a new and beautiful vision of the Universe. But for the majority of people during his own lifetime Shelley was an outcast and a blasphemer, a man whose views, as contained in his poetry and other writings, were too shocking to be tolerated. How can Shelley have provoked these two totally dissimilar reactions? How can his poetry, which was once thought so outrageous, be considered today so beautiful and rewarding?

The growth of a rebel

Percy Bysshe Shelley was born in 1792 at Field Place, near Horsham in Sussex, the son of a wealthy squire and member of Parliament. For the first few years of life he was very happy. He lived among fields and woods and had four adoring sisters who listened entranced to the tales of witches and monsters he told with such vividness that he often succeeded in terrifying both his sisters and himself.

The first cloud on his horizon appeared when he was sent to school – first to Sion House School, Brentford, and later to Eton. Shelley's strange imaginings were appreciated neither by his teachers nor by the other pupils, and he could not get used to school discipline. By the time he went to Eton at the age of 12 he was a confirmed rebel. The other boys retaliated by 'baiting' him, and he spent most of his time alone reading, writing, and thinking. Before he left Eton Shelley had written several poems and two horrific novels in the fashionable 'Gothic' style (see page 2635).

While he was at Eton Shelley read William Godwin's *An Enquiry into Political Justice*, a philosophical work which was to have a profound effect on his future thought and action. Everything that interested Shelley at this time – whether chemical experiments or philosophy – interested him passionately. And Godwin's ideas on political and social reform seemed to provide the perfect intellectual justification for his growing hatred of authority.

In 1810 his father sent him to University College, Oxford. He had been there less than a year when, carried away by the latest of his crazes, he published a pamphlet entitled *The Necessity of Atheism*, in which he explained his reasons for disbelief in the existence of God. The result was his immediate expulsion from the university. This shocked and bewildered Shelley, who was quite unable to understand other men's unwillingness to listen to the irrefutable logic of his arguments.

Shelley's expulsion from Oxford was in many ways a disaster for him – he was cut adrift at the age of 19, and his father began to resent and distrust him. All this led a few months later to his foolish elopement with Harriet Westbrook, a friend of his sisters.

Percy B. Shelley.

(FROM AN ORIGINAL PICTURE IN THE POSSESSION OF MRS SHELLEY)

O wild West Wind, thou breath of Autumn's being,
Thou, from whose unseen presence the leaves dead
Are driven, like ghosts from an enchanter fleeing,
Yellow, and black, and pale, and hectic red,
Pestilence-stricken multitudes. . . .

Ode to the West Wind

Hail to thee, blithe Spirit!
Bird thou never wert,
That from Heaven, or near it,
Pourest thy full heart
In profuse strains of unpremeditated art.

To a Skylark

I am the daughter of Earth and Water,
And the nursling of the Sky;
I pass through the pores of the ocean and shores;
I change, but I cannot die.

The Cloud

Early poems

Shelley wrote a number of poems in his late teens and early 20s. The most famous, *Queen Mab* (1813), is a strident denunciation of the existing social order in England. The ideas in it are based on Godwin's, and much of the style is borrowed from Southey and other contemporary poets. But in *Alastor* (1816) and *Laon and Cythna* (1817) a more original style begins to emerge. The revolutionary ideas in his early poems, particularly *Queen Mab*, attracted widespread attention to them and their author. Although Shelley later modified many of his ideas and expressed them in less inflammatory terms, he could not live down the reputation which these early poems had gained for him as a dangerous revolutionary.

Rather than being a revolutionary or reformer, Shelley began to realise that he was a poet and idealist in search of perfection. The language in which he expressed his feelings and ideals gradually became more controlled and less propagandist. He sought inspiration in the classical works of Greece and Rome and paid greater attention to the mechanics of writing poetry, experimenting with new verse forms and rhythms.

These new interests helped his development as a poet, but he still suffered society's disapproval as a result of his earlier writings and actions. Life in England became increasingly distasteful to him and his health deteriorated. In 1818, with his second wife Mary, he left England to live in Italy.

Italy: tragedy and triumph

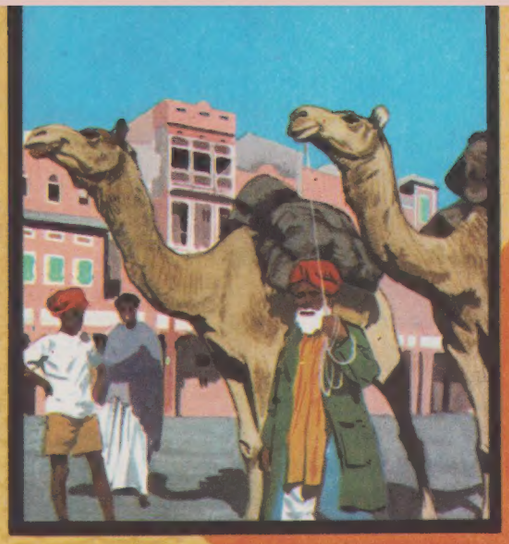
It is on the poems written between 1818 and his tragic death in a sailing accident off the coast of Italy in 1822 that Shelley's reputation as a poet is today based. In Italy his genius flourished and he produced many fine poems and his most carefully thought out prose works – *A Defence of Poetry* and *A Philosophical View of Reform*.

The most ambitious poem which Shelley wrote at this time, and the one which many people consider his masterpiece, is *Prometheus Unbound* – a 'lyrical drama in four acts' in which Shelley successfully re-creates and transforms the myth of Prometheus to embody his own philosophical view of the Universe. But perhaps the poems for which he is now best remembered are the short lyrics such as the *Ode to the West Wind*, *To a Skylark*, and *The Cloud*, which express in language of unrivalled musical harmony and beauty his unique perception of Nature. The lines from the last stanza of *The Cloud* which are quoted on the left provide a fitting memorial to this great man who died so prematurely, but who has become immortal through his poetry.

CITIES OF INDIA

A COW wanders through the busy crowded streets among the trams and cars. No one shoos it away, even if it should show signs of going to sleep in the middle of the road. For although the busy streets and tall modern buildings might be scenes from a major European city, this is India – where a cow is a sacred animal and must have its own right of way.

An incongruous scene, yes, but India is an incongruous country. Everywhere the old mixes with the new. Ancient traditions and new ways, enormous wealth and hopeless poverty, air-conditioned apartments and disease-ridden hovels – all these have combined in the development of India's cities, which are among the most varied and exciting, yet chaotic and depressing, in the world.



Jaipur. Farmers bring their merchandise on camels

Delhi. The Indian Parliament

DELHI, CAPITAL CITY (population 2,359,000)

'If there be a paradise on earth it is this, it is this, it is this.' So runs the inscription in the audience hall of the Red Fort in Delhi. Within this hall stood the fabulous Peacock Throne, covered with emeralds, rubies, sapphires, and pearls, and said to have been worth several million pounds. Delhi was the capital of the Mogul Empire under Shah Jahan, the 17th-century ruler who made Delhi the greatest city in the north. He built the Red Fort and the Jama Masjid, or great mosque, with its three white marble domes. His city forms the nucleus of Old Delhi.

But the power of the Moguls declined (see page 2226). In 1739 the Persians pillaged the city and removed the Peacock Throne. The British made Calcutta their capital; and when King George V declared in 1911 that Delhi should once more be capital of India, a completely new city, known as New Delhi, five miles to the south of the old city, was designed by eminent British architects in what might be called 'British colonial style' – western buildings with columns and pillars, broad avenues, and symmetrically laid out streets. The Viceroy's house, now the President's residence, is as large as Trafalgar Square in London. New Delhi is almost exclusively an administrative city; Old Delhi, on the other hand, is an important railway and market centre, and is famous for the hand-worked gold and silver filigree, embroidery, jewellery, muslins, pottery, and wood carving. On the plain surrounding Delhi are many ancient ruins, for according to tradition Delhi has been the site of a capital from time immemorial.

Bombay. The busy centre

CALCUTTA, THE CROWDED CITY (population 3 million)

Calcutta, near the north-east coast of India, is a huge and densely-populated city. Great houses and government buildings remind us that it was the capital of British India between 1773 and 1912; its busy docks handle a great amount of international shipping. But around these lie appalling slums, and many beggars haunt the streets.

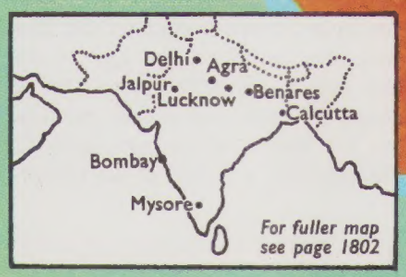
Calcutta takes its name from Kalighat, a place on a small stream running into the river Hooghly, where there is a temple to the Hindu goddess of destruction, Kali. But the nucleus of the present town was Fort William, a trading post set up by the East India Company in 1690. To the British Calcutta is notorious for its 'Black Hole', a dungeon where the Nawab of Bengal confined a captured British garrison in 1756 in conditions so fearful that 123 of the 146 prisoners perished. But the truth of this terrible story has never been proved conclusively.

BOMBAY, THE COTTON CITY (population 4,152,000)

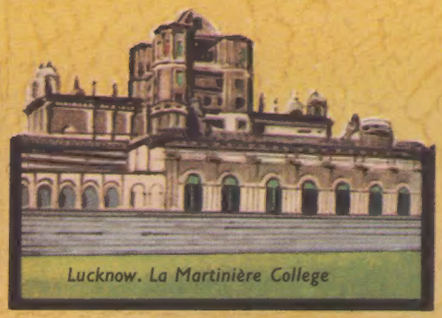
Bombay, the great port on the west coast of India, lies on an island about 13 miles long. To the east lies a fine natural harbour, 74 square miles in extent, and this port handles about one-third of India's foreign trade. Western influence is shown in the ultra-modern buses, the Gateway to India (as the entrance to the harbour built in 1911 to commemorate the landing of King George V and Queen Mary is known), and the Victoria and Albert Museum; but on Malabar Hill stand the Parsee Towers of Silence, irrevocably Eastern, where the Parsees, who worship Zoroaster and Ormazd, god of light, place their dead to be picked clean by the vultures.

The British gained Bombay in 1661 as part of the Portuguese Catherine of Braganza's dowry when she married Charles II. In 1687 it became the centre of British administration in western India, and the opening of the Suez Canal in 1869 and the starting of regular steamship services to the Mediterranean and Europe increased its prosperity. It is now the capital of the state of Bombay – the largest and richest state in India, for its rich black soil grows much cotton; and Bombay city is the greatest cotton centre in India.

Mysore. The main gateway



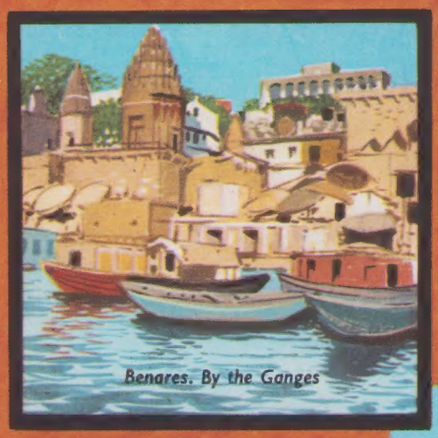
For fuller map see page 1802



Lucknow. La Martinière College

Calcutta. A beautiful Jain temple

Agra. Gateway to the Taj Mahal



Benares. By the Ganges

MYSORE, THE GARDEN CITY (population 253,000)
Some 2,500 feet above sea level stands Mysore, which is renowned for its fine silks, sandalwood perfumes, and ivory, metal, and woodwork. Its many parks and broad streets have given it its nickname 'Garden City of India'. The maharajah's palace, built in 1897, contains an elaborately carved silver and gold throne said to rival the Peacock Throne itself.

BENARES, THE HOLY CITY OF THE HINDUS (population 489,000)
About 400 miles north-west of Calcutta the river Ganges swings round in a four-mile curve. The left outer bank of the curve is steep, and tiers of steps rise from the waterfront up to the walls of the 18th-century palaces. Bathers and boats crowd the river, and the conical pinnacles of Hindu temples pierce the smoke of the burning ghats – for this is Benares, or Varanasi, the Holy City of the Hindus. For more than a thousand years it has been the centre of Hindu pilgrimage, to which the faithful come to bathe in the sacred river, believing that this will give them great physical and spiritual benefit. Many complete the 36-mile circuit of Benares called the Panch Kosi, which takes six days to complete, as many temples and shrines must be visited. Those who complete it are automatically absolved of all sins. Along the river are the burning ghats – quays of carved masonry on which funeral pyres are built. At the foot of the flights of steps stand the bathers, waist-deep in the muddy water. Great masses of Hindus crowd the lower flights, some resting under the many huge palm-leaf umbrellas. Behind the waterfront the city itself is a maze of narrow streets, crowded with beggars, *sadhus* (holy men), *gurus* (religious teachers), pilgrims, and – inevitably – sacred cows.

Most of the older temples of Benares were destroyed by Muslims, and the many temples there today are mostly 18th-century or later. Among the most beautiful is Vishwanath Temple, built by Maharani Ahalyabai of Indore in the 18th century. Its dome and spires are covered with gilt copper, given by the Sikh ruler of Punjab, and it is known as the Golden Temple.

MADRAS (population 1,729,000)
The city of Madras in the south-east of India was founded in 1649 by the East India Company, and for over a century it was the leading British settlement in India. Today it spreads over about 50 miles and is the southern terminus and headquarters of the Indian railways, with industries including engineering, car and railway coach building, textiles, and films. Its busy harbour is entirely artificial, built between 1875 and 1881.

Madras has grown up around Fort St George, built between 1640 and 1653. George Town, to the north of the fort, is the main business part of the city; to the south are the historic villages of Triplicane and Mylapore, with their many ancient Hindu temples. According to legend the Apostle St Thomas was martyred near here, and buried at San Thomé; a cathedral has been built over his reputed tomb.

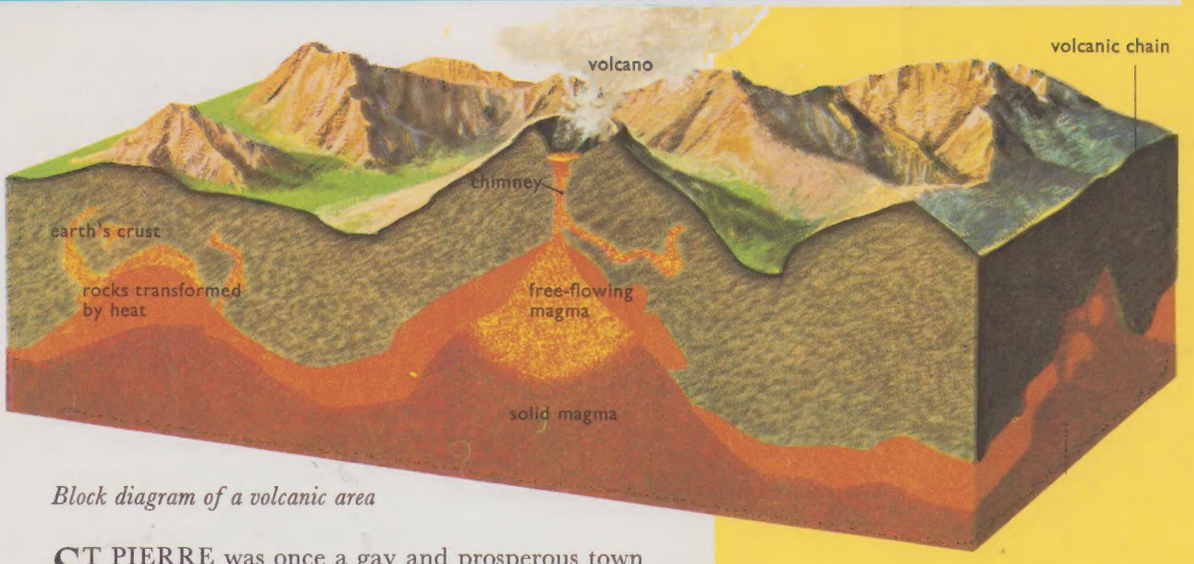
JAIPUR (population 400,000)
Jaipur, the capital of Rajasthan, is built of rose-pink stone, surrounded by embattled walls. It was built in the 18th century by Jai Singh, who studied plans of European cities but eventually built Jaipur according to principles laid down in ancient Hindu treatises on architecture. Haughty camels and handsome, colourfully-dressed Rajasthanis pass through streets flanked by lattice-windowed houses, and past magnificent palaces.

HYDERABAD (population 1½ million)
Hyderabad was founded in 1589 by Mohammed Kuli. The city is surrounded by a stone wall with 13 gates, which was built in the 18th century by the Nizam of Hyderabad, the chief Muslim ruler of India, who made it his capital. Its finest building is the Char Minar, a 16th-century mosque. Today Hyderabad is a road-rail junction, and commercial and industrial centre. It is often called Hyderabad Deccan (after the plateau on which it stands; see page 1802) to distinguish it from the Pakistani city of the same name.

LUCKNOW (population 655,000)
Lucknow, in the north of India, is the capital of Uttar Pradesh, formerly the provinces of Agra and Oudh. It was built by the Nawabs of Oudh in the 18th century, and they ruled between 1775 and 1856. Most of Lucknow's important buildings date from their rule. The British annexation of Oudh in 1856 was one of the contributory causes of the Indian Mutiny, during which the British withstood a terrible six-month siege in the Residency at Lucknow, whose impressive ruins spread over several acres on the banks of the river Gomani.

AGRA (population 508,000)
The city of Agra is overshadowed by the Taj Mahal, the most famous building in India and one of the most beautiful buildings in the world. It was built of white marble in the 17th century by Shah Jahan as a tomb for his wife Mumtaz Mahal. Agra was the capital of the Moguls until Shah Jahan shifted it to Delhi. The great fort, founded by Akbar (see page 310) has rusty-red walls 70 feet high, surrounding beautiful palaces and mosques of white marble.

VOLCANOES



Block diagram of a volcanic area

ST PIERRE was once a gay and prosperous town on the coast of the Caribbean island of Martinique; 30,000 people lived there. It was sometimes known as the 'Paris of the West Indies'. Five miles away was a volcano called Mount Pelée.

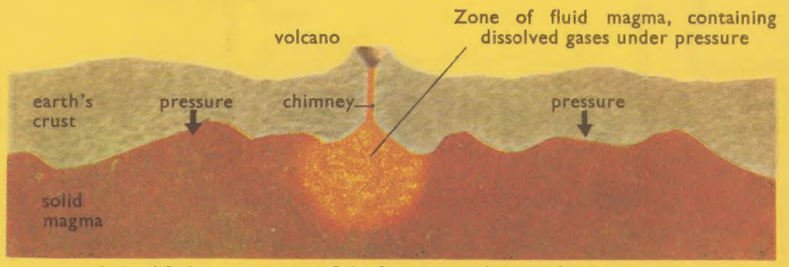
On 2nd April 1902 the volcano began emitting steam and ash. At night an ominous red cloud lay over the mountain top. In the streets of St Pierre people could hear sinister rumblings, hissings, and explosions from the depths of the volcano. Their apprehensions were even more aroused when ash coated the city to a depth of a foot. There was a smell of sulphur in the air.

Then, on 8th May, the volcano exploded. The blast shot from the side of the mountain like a great gun. A glowing cloud of gas rushed down the slopes at 100 m p h. In seconds almost the entire population of St Pierre was wiped out through burns or asphyxiation. The buildings were either flattened or burnt. In all 40,000 people died; in St Pierre the only survivor was a negro murderer locked deep underground in the city jail. Ships in the harbour were burned or sunk by waves stirred up by the boiling sea.

St Pierre is just one of the many spectacular and horrifying disasters resulting from volcanic eruptions. What dreadful forces below the earth's surface can cause such appalling occurrences? What is it that makes a volcanic eruption one of the most terrifying sights on this planet?

A terrible eruption overwhelms the town of St Pierre

The earth's crust is made of light, rigid rocks 'floating' on top of a heavier but more plastic layer (magma), rather as a block of wood rests on tar. The thickness of the upper crust varies from over 25 miles beneath mountain chains to almost nothing on the floors of ocean basins. Pressure and temperature increase with depth from the earth's surface. It is thought that the interior of the earth is made up of very dense material at very high temperature. At the base of the crust the temperature is at least 700°C. A volcanic eruption takes place when



A simplified representation of the forces at work in a volcanic eruption

pressure builds up in the magma and the material bursts upwards through a weakness in the crust to the surface. As the magma escapes the pressure upon it decreases enough for it to become molten. On its way upwards it may melt the nearby rocks of the crust or spread out in layers among them. It also gives off steam and gases which can press upwards with explosive force.

THE ANATOMY OF A VOLCANO

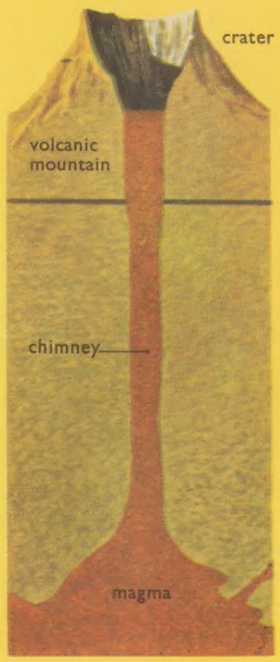
On the right is a diagram of the various parts of a volcano. The word *magma* is used to describe the material from the depths; it is not merely molten rock. It is also heavily charged with gases. These remain dissolved until pressure from above is released and the gases begin to be liberated, sometimes explosively. The molten material emitted at the surface (*lava*) therefore has little dissolved gas and is less mobile.

THE VOLCANIC MOUNTAIN is built of the accumulation of lava. It may have a conical form or be a wide spread of lava.

THE CRATER is the remains of the channel that the magma has made for itself to the surface. It is usually a depression with solidified lava on all sides.

THE CHIMNEY is the magma's route upwards; it may be single or branched.

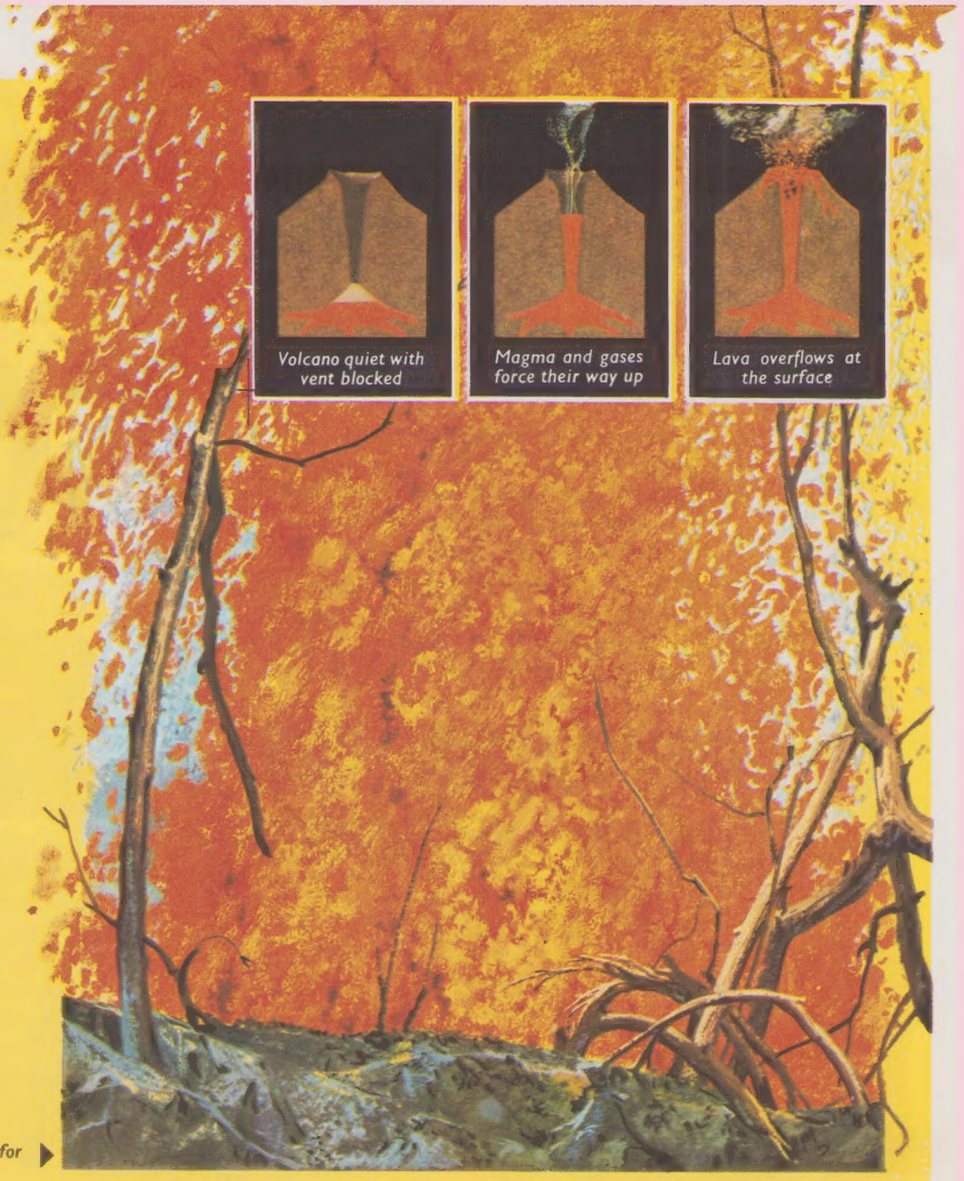
THE MAGMA RESERVOIR is usually over 20 miles below the surface. At this depth the magma is at a very high temperature (over 1,300°C).



THE LIFE OF A VOLCANO

When we talk of volcanic activity we mean all the phenomena associated with the escape at the earth's surface of magmatic materials from the depths. A violent eruption of hot lava, dust, or gases is usually only the climax to a phase of activity which may involve nearly continuous minor eruptions, explosions, and earth tremors. A volcano which has erupted in recent times is called *active*. There seems to be little pattern in the frequency and type of eruption from active vents that have been observed over a long period of time. For example, no record existed of the eruption of Vesuvius until A D 79, when – after a series of premonitory earthquakes – there came the disastrous eruption which overwhelmed Pompeii and Herculaneum (see page 1361). During the next 16 centuries Vesuvius erupted only 10 times, each outbreak being followed by a long period of 'repose'. But after the eruption of 1631 continuous activity began, with crescendoes of activity every 10 to 40 years or so. The last major eruptions were in 1906 and 1944.

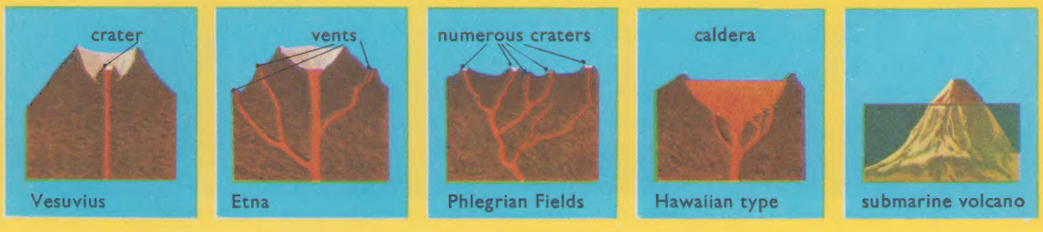
A volcanic eruption may take many forms. If the magma is stiff and sticky and there are many obstacles to its upwards thrust, the gases may burst out in an explosion like that of Mount Pelée; the lava is shot upwards as pellets, boulders, ashes, and cinders, which for some time afterwards rain from the sky. These materials are known as *pyroclasts*. But if the magma is a free-flowing liquid, the gases within it may simply bubble to the surface with few violent explosions; when the lava rises it may overflow the crater or break through *fissures* in its sides. At the initial stages spectacular 'lava fountains' may be seen, at night forming glowing red curtains of fire. The volcanoes of the Hawaiian Islands behave in this way; a Hawaiian 'lava fountain' is illustrated on the right.



The eruption of Kilauea in Hawaii in 1955; a great column of lava rose for 12 days

VARIOUS TYPES OF VOLCANO

According to the number and disposition of their craters volcanoes are divided into several different types, which are illustrated and described below.



Vesuvian type. This type seems to have only one main vent. The lava is pasty, and during eruptions strong explosions may take place. There is a large crater, within which stands a secondary cone of volcanic ash.

Volcanoes of the Mount Etna type. Here again there is a large central crater, but separate vents lead off from the chimney, and occasional eruptions take place when an opening is forced in the side of the cone itself.

The Phlegrian Fields is a unique area near Vesuvius where no fewer than 19 separate craters are seen within 25 square miles. Many of the craters emit gas, but others now contain attractive lakes.

The Hawaiian type. Mobile lava is emitted more or less quietly from this type of volcano. The enlarged crater formed by the collapse of the sides inwards is called a *caldera*. This is filled by a bubbling lava lake.

The Hawaiian islands are volcanic mountains, which have built up some 15,000 feet from the ocean floor. Only the tops are seen. The rapid cooling of lava beneath the sea produces *pillow lava*.

WHERE VOLCANOES ARE FOUND

Some 500 volcanoes are known to be active; in addition to these there are many thousands of well-preserved cones which have to be considered in outlining the distribution of recent volcanoes.

Most volcanoes are found along the lines of recent mountain building (known as *orogenic belts*). Thus many are found around the fringes of the Pacific, and some writers have referred to these as the Pacific 'girdle of fire'. Vents can be traced sporadically along the Alpine-Himalayas orogenic belt. They are also associated with the extensive rift valley faulting which runs from Jordan to East Africa.

Volcanic activity everywhere takes full advantage of fracturing in the earth's crust; along the most profound of such fractures – the fold mountain belts and deep-seated faulting – we find most of the world's recent volcanoes.

SOUTH AMERICA: coast and islands

IN 1520 Ferdinand Magellan discovered a sea route from the Atlantic to the Pacific (see page 520). This was a major step forward in European knowledge of the South American coastline. In 1532 the cartographer Sebastian Münster produced a map of the American continent. In the map South America bore some relationship to its correct shape, for he realised that it was roughly triangular, tapering to the south. But his knowledge of the interior was limited. The south he thought to be inhabited by a race of giants. In 1562 another map appeared. The belief in giants was still there; the Amazon sprawled across the continent like a great snake; and the rivers Plate and Parana stuck into it like a huge tree-stump. But the map was recognisable as South America. Since then our knowledge of the 15,000-mile coastline has been continually increasing, and now almost every mile is known and mapped.

The Galapagos Islands with their volcanic hills and sharp crags

The Atlantic coast: from Guiana to Patagonia

Much of the eastern coast of South America is backed by the Brazilian plateau. In some places there is almost no coastal plain, as at Rio de Janeiro where the plateau meets the sea, but in others it is 30 to 40 miles wide. The widest parts are in the south where the plateau gives way to the Uruguayan pampas and in the north where the Amazon valley dominates. The low cliffs on the coastal plain, the long beaches, dunes, and offshore reefs, show the effects of uplift and submergence. Along much of this coast the typical vegetation is forest, and in the past sailors called it 'the long green line'.

Around the estuary of the Rio de la Plata the coast is low-lying and hemmed in by sand dunes, behind which are fertile alluvial soils brought down by the river. These support a rich growth of grass which feeds cattle for the Buenos Aires market.

South of the Rio Negro the dune coast is replaced by steeper cliffs and valleys. The eastern edges of the plateau of Patagonia have suffered from erosion by the sea, and the cliffs so formed range in height from 50 feet in the north to 1,800 feet in the south.

Petroleum from the sea

The Caribbean coast has only one bay of any significance, Lake Maracaibo, which stretches inland for about 75 miles and is up to 150 miles wide. Its seascape has been transformed by a forest of derricks used to extract the rich 'black gold' from the bottom of the sea. This region produces 60 per cent of Venezuela's petroleum and helps the country's output to rank third in the world. The gulf is shallow, and dredging is necessary to maintain a deep channel up to Maracaibo City. In past centuries the Caribbean coast was a famous haven for pirates.

In Tierra del Fuego: a glacier plunging to the sea over a lava flow

The Pacific coast: southern fjords, northern cliffs

The coast of Chile south of the island of Chiloé has been called the 'Norway of the south'. Here the Andes decrease in altitude, splitting off into numerous islands, submerged valleys, glacier-fed lakes, and picturesque fjords, while east of the mountains there are considerable ice-fields which isolate southern Chile from Argentinian Patagonia.

North of the fjord region the western coast of South America continues uninterrupted to the northern tip of the continent. The whole of this long section of coastline is dominated by the Andes. This high range runs parallel to the coast from southern Chile to Panama, and its crests are rarely more than 100 miles from the sea. Along this coast there is only one harbour of any significance – at Guayaquil, the largest city and most important port of Ecuador.

Rio de Janeiro, where the plateau edge meets the Atlantic. In the foreground is the famous 'Sugar Loaf'

THE PENINSULAS

Unlike Europe, South America has few peninsulas. Guajira, in north-east Colombia, is the only one of any significance. It has moderate relief with no peaks above 2,600 feet. Although the natural vegetation there is forest, volcanic soils allow much subsistence agriculture.

On the west coast the Taitao peninsula juts out to interrupt the sheltered north-south route between the islands off the broken coast of southern Chile.

ARCHIPELAGOS

Only 650 miles from Antarctica, at the southern end of South America, is the archipelago of Tierra del Fuego – named after its largest island. The land area of the full group is 27,476 square miles, but it is sparsely populated. The land is barren, the climate bleak, and in many respects the islands are reminiscent of the Scottish moors. But, strangely, the title 'Tierra del Fuego' means 'land of fire'. This description was coined by Magellan who, when first negotiating the strait that bears his name, saw active volcanoes on both sides of him.

The only other important archipelago is the one which lies off the Chilean coast. It is made up of about 2,000 islands, few of which are inhabited. The great majority of the people live on Chiloé, the largest island, where fishing and some farming provide employment.

Tierra del Fuego – the archipelago lying off the southern end of South America

THE ISLANDS

The islands can be divided into two major groups: the 'offshore' and the 'inshore'. In the former group are the Falkland Islands in the South Atlantic, and the Galapagos Islands off the coast of Ecuador. The Falkland Islands are bleak and inhospitable, the fjord-like sounds between the islands showing evidence of former glaciation. The dominant relief is low ridges, more or less devoid of vegetation. These islands are known for the severe gales that constantly rage there, and for the large numbers of sheep that graze on them. The Galapagos Islands consist of barren lava fields fringed by mangrove swamps. They are of little economic significance but are famous for the giant tortoises (galapagos) which inhabit them; these are near to extinction as a result of unrestricted hunting for their eggs and oil. Other wild life abounds.

Marajo, the only large inshore island, lies in the mouth of the Amazon which it has separated into two large distributaries – the Amazon proper in the north and the Para in the south.

Mercenary soldiers (left) and army officers at the time of the Thirty Years War

THE THIRTY

EVERYONE expected war. In 1621 the 12-year truce between Spain and the United Provinces was due to expire. Clearly Spain would make another attempt to bring these rebellious Dutchmen to heel. But war broke out sooner than expected – not in the Netherlands but in Germany. In 1618 the Protestants in Bohemia rebelled against the authority of the Emperor. This was the beginning of the Thirty Years War, a war so horrible that no historian can adequately describe the misery it brought. Around this conflict developed wider struggles. Soon armies from Denmark, Sweden, France, and Spain were trampling across Germany, adding to the chaos wrought by the German armies and hired mercenaries who were plundering German cities, exterminating their inhabitants, and ruining the economy as they 'lived off the land'. Such was the devastation that German people were reduced not only to starvation but sometimes to cannibalism.

The Thirty Years War was not one war but a series of wars. The enmity between Catholic France and the Catholic Habsburgs of Spain and Austria, the hostility of the Dutch towards Spain, the struggle for control of the Baltic – all these resulted in armed conflict on German soil. In addition there was the basic conflict between Reformation and Counter-Reformation. In Germany the Protestant Union of German Princes opposed the Catholic League headed by the powerful Maximilian of Bavaria. All these conflicts merged into one of history's most terrible wars.

Main troop movements during the Thirty Years War

THE PROTESTANT REVOLT

In March 1618 a dramatic event took place in Prague. Two Catholic officials of the Emperor were thrown out of a window by Protestant rebels. This was the signal for revolt, and soon all Bohemia was in arms against the Emperor. The Bohemian Protestants offered their crown to Frederick, Elector of the Palatinate and son-in-law of England's James I. Frederick accepted, and rather than see the Elector acquire Bohemia, Maximilian loosed the army of the Catholic League against the rebels. Tilly, the League's commander, routed Frederick at the battle of the White Mountain in November 1620. The Elector fled into exile.

After Tilly's victory some of the Protestant princes became apprehensive at the increase of Catholic, and especially Bavarian, power. Christian of Brunswick and George Frederick of Baden-Durlach joined with Mansfeld, leader of the mercenaries who had aided Frederick. In the spring of 1625 the Protestants were dramatically joined by Christian IV, King of Denmark, who invaded Germany not only to aid Protestantism but to pursue Danish interests along the Baltic shore.

FOREIGN INVASION

It was soon apparent that Tilly's army was no match for the new enemies of the Emperor Ferdinand. Out of this crisis arose the most enigmatic of the war's leaders, Wallenstein. This fabulously wealthy and ambitious nobleman offered to raise an army himself in the service of the Emperor. The offer was accepted. In 1626 Wallenstein defeated Mansfeld; and Tilly, with part of Wallenstein's army, routed Christian of Denmark. There was now no force in Ger-

YEARS WAR

many to match the armies of Tilly and Wallenstein. But Catholic and Protestant princes alike became alarmed by the activities of Wallenstein. In 1628 he began to occupy his new duchy of Mecklenburg and also to occupy adjacent towns. Did he intend to carve out a Baltic kingdom?

In 1630 the Catholic princes prevailed on the Emperor to dismiss Wallenstein – just as Gustavus Adolphus of Sweden arrived in response to an appeal from the Protestants to intervene.

SWEDISH INTERVENTION

In the sordid story of intrigues, opportunism, and greed which characterise the Thirty Years War the dazzling career of Gustavus Adolphus flashed across the European scene with all the brilliance of a comet. He was hailed as the champion of Protestant Europe, and his troops won a completely crushing victory over the Imperialists at Breitenfield and defeated (and mortally wounded) Tilly on the Lech. Ferdinand had no alternative but to recall Wallenstein. At Lützen, in 1632 the two great commanders came face to face. Wallenstein's men were driven from the field, but the great Gustavus himself was slain.

Famous leaders of the Thirty Years War

Ferdinand planned to make a quick thrust in alliance with Spain against the Protestants. Wallenstein, whose own religion was a belief in his own destiny as foretold by the stars, had different ideas. He refused to obey Ferdinand's orders and for the second time was dismissed. Wallenstein then tried to arrange a combination of his army, and the Saxons, and the Swedes, which, he hoped, would impose peace by force. But in February 1634 Wallenstein was murdered by his own troops with the sanction of the Emperor.

Troops from Wallenstein's army pillage a town they have conquered

THE SUPREMACY OF FRANCE

The death of Wallenstein removed all hope of German unity and ushered in the most terrible period of the war. So far France, ruled by Cardinal Richelieu (see page 2384), had taken no active part in the war, though she had largely financed the campaigns of Gustavus Adolphus. After the Swedes suffered a terrible defeat at Nordlingen in 1634 Richelieu declared war on Spain, and the armies of Spain, Austria, and the League, the United Provinces, France, and Sweden battled largely on German soil. It is impossible to recount here the complex series of battles or the peace negotiations which characterised the last years of the war. At one stage it seemed as if Spain and Austria would triumph as the Dutch retreated and France was invaded. But in 1643 the French shattered the Spanish troops at Rocroi, and it became clear that the Habsburgs were fighting a lost cause. The Peace of Westphalia (1648) acknowledged German disunity. The princes could adopt the Protestant faith (Lutheran or Calvinist), and conduct even their own foreign policies, without reference to the Emperor.

Europe at the end of the Thirty Years War

ADEN

IN 1839 Aden was annexed with very little fuss by Great Britain. The commander of the expedition which took it noted: 'The little village (formerly the great city) of Aden is now reduced to the most exigent condition of poverty and neglect. In the reign of Constantine this town possessed unrivalled celebrity for its impenetrable fortifications, its flourishing commerce, and the glorious haven it afforded to vessels from all quarters of the globe. How lamentable is the present contrast.'

Under British rule the 'exigent condition of poverty and neglect' did not last long – but Aden's down-at-heel appearance and forlorn air of a penal settlement did. However, Aden was by no means to be just another British colony annexed almost in a fit of political absent-mindedness. The opening up of the Suez Canal in 1869 made Aden an important coaling station, because of its natural harbour and its position at the mouth of the Red Sea. And throughout its history Aden has continued to serve the strategic interests of Britain – a base for the protection of British oil interests in the Middle East, and a staging base in Britain's world-wide defence network. And that is why in 1964 the guns and jets of Britain's armed forces went into action to maintain the security of the colony.

COLONY AND PROTECTORATE

Aden is the name of a British Crown Colony and the surrounding district. It lies on the south coast of the Arabian peninsula, close to the Red Sea. The colony, some 35 square miles in area, consists of two peninsulas joined by a narrow strip of hinterland – also an island in the Red Sea called Perim and the Kuria Muria Islands in the Arabian Sea. The surrounding district or Protectorate consists of a number of tribal states which have treaties making Britain responsible for their defence and external affairs. It is divided into the Western Protectorate, which has an area of 40,000 square miles and consists of a coastal plain behind which lies a mountainous plateau, and the Eastern Protectorate, 70,000 square miles in area, consisting largely of desert and mountains. Some of the tribal districts and the colony (now known as Aden State) – but not the islands – have joined together in the Federation of South Arabia. It is planned that this will become independent in 1968.

The climate over most of the region is pleasant in winter but hot and humid in summer; rainfall is extremely low. There are few made roads, and transport is mainly by camels and donkeys, though trucks can be used and there are some internal air services.

The people of the Protectorate are Arabs, but the State's population, although mainly Arab, includes many Yemenis, Indians, Somalis, Europeans, and Jews. The people of the State are largely employed in the port or in cleaning, sorting, and packing goods for export, and also in the colossal British Petroleum oil refinery. Industries include oil-refining, the crushing of oilseed, and the manufacture of soap, aluminium ware, and cotton cloth.

Aden State: a view of the harbour and airport

The inhabitants of the Protectorate are almost all employed in agriculture. Crops are dependent on irrigation from wells and water courses, and include cotton, millet, wheat, barley, dates, sesame, and lucerne; sheep, goats, cattle, donkeys, and camels are reared. Fisheries provide important exports, including dried sardines, tunny, and sharks. Gold- and silver-work, weaving, and dyeing are the main industries of the Protectorate.

THE HISTORY OF ADEN

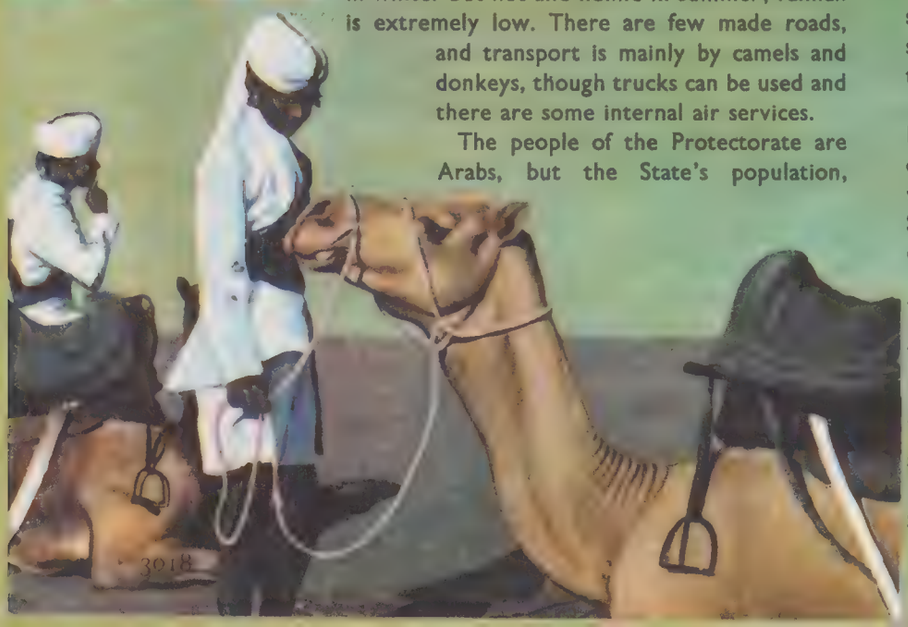
The port of Aden has been an important trading post and port of call since very early times. Goods from India, China, Indonesia, and Africa arrived there and were transported by camel caravans or via the Red Sea to Egypt and thence to Europe. Although we know little about the early history of Aden, we do know that it was flourishing before the Romans and that Marco Polo, returning from the East in 1295, found it a wealthy and prosperous port.

The development of shipping routes round the Cape of Good Hope led to a decline in the prosperity of Aden. But after the 19th-century annexation by Britain Aden began to expand again.

The British consolidated their position by acquiring more land around the port. Perim was acquired in 1857; Little Aden (the smaller of the two peninsulas) was purchased in 1868 and the coastal strip in 1882 and 1888. A number of treaties were made with the tribes of the hinterland.

In this period Aden was ruled from India, first as part of the Bombay Presidency and then as a province under the direct control of the Government of India. This was resented by the people of Aden who protested to London and New Delhi, and on 1st April 1937 the Settlement of Aden became a Crown Colony under the direct control of the Colonial Office in London.

The traditional enemies of Aden and the Protectorate are the Yemenis. They have always claimed that this part of the South Arabian peninsula should belong to them – a claim never allowed by the tribal rulers in the Protectorate. The borders between the Protectorate and the Yemen have seen constant fighting by Yemenis and border tribesmen against the troops of the Protectorate aided by the British.


Soldiers and camels of the Federal Army

THE AQUARIUM

YOU may have felt after a visit to a zoo that it would be very pleasant to have a zoo of your own. Of course, you can keep a pet – a dog, a cat, or a budgerigar. But perhaps you want something more exotic – to be able to watch creatures behaving as if they were living in their wild state. The easiest, cheapest, and most convenient way to satisfy this wish is to have a small aquarium.

The tank. By far the best aquarium is a rectangular tank with glass sides held in a metal frame. Start with one tank and get a fairly large one: 24 inches long by 12 inches wide and 12 inches deep is a good size. This will hold about 13 gallons of water and weigh about 180 pounds, so it must be set on a strongly made table. It may seem a little extravagant to start with such a large tank, but fish will thrive much better in it than they would in a smaller container. Place the tank in a good light, but not next to a window. Strong sunlight may overheat the water, and it encourages the growth of microscopic green algae which cloud both the water and the glass. Also you can see the fish much better if you look at them with the light behind you. If you are going to keep tropical fish (there is nothing difficult about this) the tank must be fairly near an electric wall-socket.

The water. Put 2 inches of well-washed coarse sand in the bottom of the tank and fill it to an inch or so below the top with rainwater or clean pond water. Never try to move the tank when it is full, as this will strain it and cause it to leak. A cover made of wood and netting should be kept over the aquarium to keep active fish from jumping out and the cat's paws from getting in. For tropical fish the water must be warmed to about 75°F. This is done by an immersion heater combined with a thermostat, and the dealer who supplies it will explain how to install and work it.

The fish. When you put the fish in do not overcrowd them; this is a common cause of failure. The air which they breathe enters the water through the surface, so the number of fish you can keep depends on the surface area. Fish 2 or 3 inches long need 8 to 10 square inches each, so in your 24 by 12-inch tank you can have about 30 of this size. You can increase the number if you have an aerator – that is, a pump bubbling air into the water.

Maintenance is not difficult. There is no need to change the water, but from time to time a rubber tube should be used like a vacuum cleaner to siphon out dirt that has accumulated on the sand; then top up the water to its former level. Do not give the fish more food than they will eat immediately, and be sure to remove without delay any fish that have died.

The fish shown above is the beautiful Siamese fighting fish (*Betta splendens*). You cannot have more than one male in a tank, as they fight.

PLANTS FOR THE AQUARIUM

Water plants, growing in the sand at the bottom of the aquarium, greatly improve its appearance and also help to keep the fish healthy. This is because (like all green plants) they carry out photosynthesis, in the course of which they absorb carbon dioxide and give out oxygen. They grow well in the sand; never put soil in the tank. Here are some suitable species of plants.

Elodea canadensis. A Canadian plant that now grows wild in Britain; it is an excellent 'oxygenator' for a cold-water aquarium.

Cabomba aquatica. A very ornamental native of America, which can be grown in a cold or heated aquarium; it needs fairly strong light.

Myriophyllum spicatum. A native British plant known as water milfoil, which grows well in a tropical tank and is very ornamental.

Swordtail (*Xiphophorus helleri*). A very pretty fish, easy to keep and quite easy to breed. Only the male has the sword-like extension on the lower lobe of its tail. The swordtail is a native of southern Mexico.

Platy (*Xiphophorus maculatus*). These fishes have been bred in a variety of colours – red, blue, black, and golden – and they can be crossed with swordtails to produce fertile hybrids. Both species belong to a family of fishes which do not lay eggs but bear their young alive.

Three-spot gourami (*Trichogaster trichopterus*). One of the labyrinth fishes, so-called because of a complicated air-breathing organ just above their gills. The Siamese fighting fish is also a labyrinth fish, and both species come to the surface at intervals to breathe air. The males of both species make a floating nest of sticky bubbles in which the eggs are lodged. They then guard them until they hatch and look after the babies for some time afterwards. The females play no part in bringing up their young.

Zebra fish (*Brachydanio rerio*). A very active, lively little fish of the carp family, native to India. It lays eggs and is easily bred.

Goldfish (*Carassius auratus*). This is the only cold-water species in our picture; all the rest are tropical fish requiring warmed water. If well fed the goldfish soon grows too large for a small aquarium, but will thrive in a garden pond. It came originally from China.

Barbus tetrazona. This beautiful little carp is a native of Sumatra. It is best to have half a dozen of them, and they will swim up and down the tank keeping close together.

Harlequin fish (*Rasbora heteromorpha*). There are numerous species of the genus *Rasbora*, and many of them are very suitable for the aquarium. This one is the best known of them, and it is very popular because it is so pretty. It comes from Malaya and Sumatra, where it is found in ditches and swamps.

Neon fish (*Hyphessobrycon innesi*). This is one of the most brilliant of all the little freshwater tropical fishes; its blue sides look like strips of neon lighting. If it gets frightened or chilled its colours become dull. It comes from the Amazon and is a very small species, hardly ever over an inch long; nevertheless, it has been known to live for ten years.

Widowfish or **black tetra** (*Gymnocorymbus ternetzi*). A handsome fish belonging to the same family (Characinidae) as the neon fish. It is a native of tropical South America.

Angel fish (*Pterophyllum scalare*). This is one of the most familiar and beautiful of the tropical aquarium fishes; like so many of them, it is a native of the Amazon region of Brazil. In the wild state angel fishes grow to 10 inches, but attain only half this size in captivity. They are rather delicate, so do not try to keep them at first, but wait until you have had some experience.

Apparatus for a tropical aquarium: ① aerator; ② filter; ③ immersion heater; ④ thermostat; ⑤ thermometer. Only ③, ④, and ⑤ are really essential

Armoured catfish (*Corydoras paleatus*). There are several species of these small tropical American catfishes, and *paleatus* is the most common. They all have two rows of bony plates along their sides, and are useful scavengers as they live on the bottom eating scraps of food left by other fishes. Like the labyrinth fishes, they have an air-breathing organ and frequently come to the surface for a bubble of air.

FEEDING

The first golden rule for feeding fishes in an aquarium is not to give them more at one time than they will eat immediately. In a heated tank food lying about at the bottom goes bad very quickly and will poison the water and quickly kill the fishes.

Dried fish foods are sold by dealers. An aquarium with from 20 to 30 fishes needs as much of this powdered food as can be

placed on a sixpence twice a day. As well as this your fish need live or freshly killed food. Finely chopped small earthworms, for example, are excellent, but you should never give them starchy foods such as bread.

BREEDING FISHES

When you have some experience with a 'community' tank – that is, one with a number of fishes of different species – you may like to try breeding some of them. If you have live-bearers (swordtails or platies) in the community tank they will probably produce young, but these will certainly be eaten soon after they are born.

To breed fishes, then, you must obtain some smaller tanks, which must be heated and maintained in the same way as the large one. If you notice a female swordtail or platy looking rather stout, put her by herself in a small tank and keep a watch for the tiny baby fishes she will probably bear. As soon as you see them remove her. A few days previously get several jars of tap water and put in each one a lettuce leaf and a spoonful of water from a pond. After a time the water will go cloudy due to the presence of thousands of minute animals called infusoria or, more correctly, protozoans (see page 2852). A little of this water every day will provide food for the baby fishes. When they have grown a bit give them the small crustaceans called brine-shrimps, whose eggs are sold by aquarium dealers for this purpose.

Egg-laying fishes are more difficult to breed. You will find instructions on how to deal with them in books on aquarium keeping.

GASTRIC AND DUODENAL ULCERS

① *This X-ray picture shows a stomach filled with a barium meal. The irregularity on the lesser curvature is a large gastric ulcer filled with barium*

② *X-ray showing an ulcer in the first part of the duodenum*

JUST as an injury can cause a small area of the skin to break down into a shallow depression known as an *ulcer*, so, too, can an injury cause an ulcer in the walls of the organs which make up the digestive system. Ulcers in the digestive system are known collectively as *peptic* ulcers (*pepsis* is the Greek word for digestion), though to distinguish those which occur in the stomach from those which occur in the first part of the duodenum the names *gastric* ulcer and *duodenal* ulcer are often used.

Peptic ulceration is a disease which has increased remarkably during the last 50 years, particularly in the highly developed countries of the world. It has often been suggested that it is one of the consequences of the worry, tension, and complexities of living in the 20th century.

The precise form of the injury which causes the mucosa of the alimentary tract to ulcerate remains rather a mystery. Undoubtedly the strong hydrochloric acid in the gastric secretion may sometimes attack the mucosa of the stomach and the duodenum, and so too may the digestive enzyme called *pepsin*. Furthermore, the constant rubbing of food particles as they pass along the intestinal tract (particularly if they are large and ill-chewed) may cause additional damage. Since, however, all of these factors are present in almost every stomach and duodenum they cannot alone be the cause of the ulceration.

A section of a part of the stomach wall, showing a gastric ulcer which has penetrated down to the muscle layer

Common sites of gastric and duodenal ulcers

THE SYMPTOMS OF AN ULCER

Ulcers occur most commonly in males, and in particular in thin men with worrying, restless, and over-conscientious temperaments. This type of person is often quite successful in business or in one of the professions, and as a result it is found that ulceration of the stomach and duodenum occurs particularly frequently in people with positions of responsibility. But it is, of course, their temperament as much as the work they do that causes it.

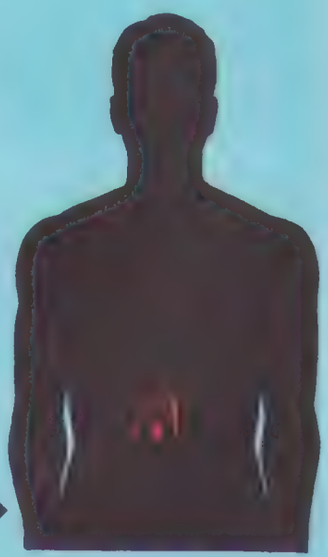
The first symptoms of an ulcer are attacks of indigestion. These may last for only a few days and be separated by long symptom-free intervals. It is worth noting, however, that they usually occur at a time of stress caused by worry or particularly hard work.

As the illness progresses the attacks become longer and the intervals between them shorter, until, after a time which may be weeks or years, the victim suffers from pain almost continuously. This ulcer pain is dull and aching rather than sharp, and it is usually felt in the *epigastrium*, the central part of the abdomen above the umbilicus. In duodenal ulceration the pain is often just a little to the right. It is almost always relieved by food, a milk drink, or sodium bicarbonate, all of which neutralise the hydrochloric acid secreted by the stomach.

THE DIAGNOSIS OF A PEPTIC ULCER

The symptoms of a peptic ulcer are so characteristic that it is usually possible for a doctor to diagnose the illness on the patient's history alone. Examination of the patient and the discovery of tenderness in the epigastrium confirm the diagnosis. But it is often difficult to distinguish between gastric and duodenal ulcers merely on the history and symptoms, and when such a distinction is thought necessary tests must be carried out in hospital. The test which is usually performed first is carried out in the X-ray department. It is known as a *barium meal*, and it is not at all unpleasant.

Barium is a heavy metal which is opaque to X-rays. In the form of its sulphate it is so insoluble as to be non-poisonous. It can therefore be made into a cocoa-



A gastric ulcer usually causes pain in the epigastrium. In duodenal ulceration the pain is sometimes, but not invariably, experienced at a site a little to the right of the centre

flavoured drink which the patient can swallow. Once the drink has been taken it fills the stomach and the first part of the duodenum so that X-ray pictures taken at this moment reveal the shape of both organs. The cavity of an ulcer is also filled with the barium and consequently it may appear as a small irregularity at the edge of the shadow.

Of course an ulcer on the front or rear wall of the stomach is not seen in profile and therefore cannot always be detected by means of a barium meal. The same applies to many ulcers of the duodenum, but, since duodenal ulcers usually cause strong contractions of the muscles in the wall of that organ, the shape of the shadow as a whole is abnormal and this, in itself, is sufficient evidence of an ulcer.

Occasionally it is necessary to perform a further test. The surgeon uses an instrument called a *gastroscope* which he gently passes down the throat until the light and lens at its lower end enter the stomach. He can then look around the inside of the organ and observe directly the condition of the mucosa.

COMPLICATIONS

Though peptic ulceration is a quite serious illness, many people who suffer from it manage very well for many years, even a lifetime. They learn to accept the pain which the ulcer causes, and they acquire many tricks of diet and behaviour which keep the pain from their ulcer to a minimum.

Less fortunate, and perhaps less careful, victims of peptic ulceration sometimes suffer from one or more of the complications of this illness. In this event the patient must usually be treated in hospital, where he may even have to have an operation.

This illustration shows how a peptic ulcer may penetrate the intestinal wall and thus produce a perforation.

Perforation – Some ulcers, particularly those of the duodenum, penetrate so deeply that a hole is made right through the wall of the intestine. This *perforation*, as it is called, needs to be closed by surgery.

Haemorrhage – Some ulcers involve the blood vessels which run through the walls of the stomach and duodenum. As a result blood may escape from the vessel into the cavity of the bowel. Repeated losses may lead to severe anaemia (see page 2998).

Scarring – Chronic ulcers are always surrounded by scar tissue. This fibrous tissue often contracts and deforms the stomach or duodenum. If the deformity is severe the passage through the alimentary canal may be impeded.

Gastric ulcer scar causing an hourglass *deformity*

Obstruction of the duodenum

These illustrations show how an ulcer scar may contract and obstruct the passage of food

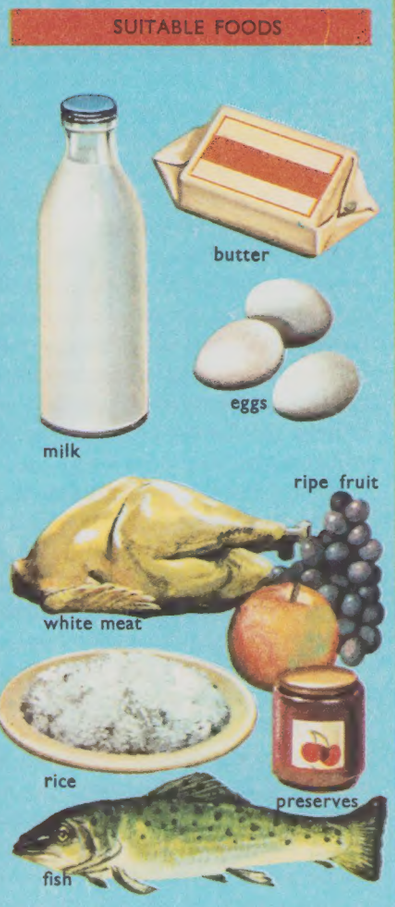
THE TREATMENT OF PEPTIC ULCERATION

Peptic ulceration can be treated either medically or surgically. In the case of an ulcer which has only recently formed, it is always worth while to attempt a cure solely by medical means. Ulcers which have been present for a long time rarely respond to such treatment and have to be dealt with by surgery.

Rest in bed for at least a month is the basis of the medical treatment of a peptic ulcer. A very light diet – chiefly of milk and fish – is given to rest the stomach, and between the frequent meals the gastric hydrochloric acid is neutralised by alkaline medicines. Belladonna is given to relax the stomach muscles and to reduce the amount of secretion. All kinds of work are forbidden.

When the pain goes the patient is allowed to get up a little and his diet may become more generous and varied. White meat, fruit, and grated vegetables may be included.

So long as the patient does not relapse he may slowly return to a more or less normal way of life. He must, however, eat carefully at regular times for the rest of his life, and avoid highly seasoned food, pickles, black coffee and strong tea, wines and spirits, and cigarettes.



SURGERY FOR PEPTIC ULCERATION

When medical treatment of a peptic ulcer provides a poor result it may be superseded by a surgical operation. The complications of a peptic ulcer, also, are often dealt with surgically. Several different kinds of operation are performed, all of them designed to reduce the gastric secretion so that the ulcer can heal.

EDWARD THE CONFESSOR

IN the 11th century the history of England emerged from the pattern of the Dark Ages. In the Dark Ages we read mainly about the doings of kings and the higher ecclesiastics, of wars and great battles. In the 11th century history becomes less simple. The character not only of kings but of the great men of the kingdom begins to emerge, and the roles of the latter become more important. Foreign policy occupies a predominant place in the minds of the rulers – not just the necessity of arranging marriages with powerful European ruling houses, but the political attitudes of Denmark, Norway, Normandy, France, and the Empire become of vital importance.

As far as can be judged many of these changes took place in the reign of Cnut (see page 2999). In dividing his kingdoms into great administrative earldoms he made the personality of the earls more important, and because he possessed a great Scandinavian empire England became intimately involved with the politics of northern Europe. It is in the 11th century also that we begin to be aware of the force of 'public opinion' – in fact, it is significant that in 1042 when Edward the Confessor came to the throne a chronicler notes: 'All folk received him to be king.'

Edward the Confessor was to be the last ruler of the West-Saxon house – the house of Alfred. This house was deposed when Cnut succeeded Edmund Ironside in 1017. From 1017 until 1042 England was under the rule of three Danish kings: Cnut and his two sons, Harold and Harthacnut. When Harthacnut died in 1042 there was no natural heir to the Danish house, so Edward was recalled.

Ironically, Edward was more of a foreigner than the Anglo-Danish kings. He had fled with his father Ethelred the Unready to the court of Normandy in 1013, after Swein of Denmark's invasion. He remained there until his accession. His mother was Emma, daughter of Richard, Duke of Normandy, so naturally his sympathies tended to be Norman rather than Danish or Anglo-Saxon.

It is possible that Edward's character has been underestimated. Canonised after his death, he was called 'confessor' for the almost excessive piety of his life. On the other hand he was capable of acting with decision and vigour, especially in the early part of his reign.

On his accession the country was dominated by Earl Godwine of Wessex, an extremely powerful and forceful magnate. Godwine's sons, Swein and Harold, both had large earldoms. In 1045 Edward married Godwine's daughter. But around his court he had gathered a powerful Norman party, hostile to Godwine. The foremost of these was Robert of Jumièges. In 1051, much to Godwine's annoyance, Robert became Archbishop of Canterbury. The clash between Edward and Godwine came the same year. Godwine disobeyed an order of the King's but was not strong enough to triumph over Edward. Earls Leofric of Mercia and Siward of Northumbria both came to the King's aid. Godwine and his son Harold were forced to leave the country. The Normans were now supreme – underlined when, probably in 1051, William of Normandy visited Edward and may have been promised the succession.

In 1052 Godwine and Harold returned – this time in such strength that Edward had no choice but to restore them to their former powers and to banish many of the Normans from his court. Only seven months after his return Godwine died, and his earldom of Wessex passed to Harold. In 1055, on the death of the fierce and redoubtable Siward, conqueror of Macbeth of Scotland (see page 1809), Tostig, Harold's brother, became Earl of Northumbria. The house of Godwine was now in a position of considerable strength, and yet it was not predominant. Leofric of Mercia, and later his son, Aelfgar, who succeeded him as Earl in 1057, were nearly if not quite as powerful. The house of Godwine had now changed its role from opposition to support of the King, and Edward increasingly relied upon Harold as his reign progressed. Opposition to Harold came mainly from Mercia.

Edward's interest in politics had begun to wane after his humiliation by Godwine in 1052. He became increasingly preoccupied with religion and his plans for the great abbey which was to be built at Westminster. Meanwhile the country remained divided, and over the sea the eyes of William of Normandy and the already legendary Harald Hardrada of Norway were on Edward's throne – the richest prize in northern Europe.

Records of the reign do not tell us a great deal about the internal politics of the later period. We know that Earl Aelfgar of Mercia was a turbulent influence and allied with the powerful Welsh ruler, Gruffydd ap Llywelyn. It was after his successful campaigns against Gruffydd that Harold first gained a predominant position in the country. In fact, with the death of Aelfgar of Mercia in 1062 and the succession to his earldom of his son, the young and inexperienced Edwin, there was no strong personality opposing Harold.

Harold must now have realised that the crown of England was in his reach. There were three possible claimants: Edward's great-nephew Edgar; Edward's cousin William, Duke of Normandy; and Harald Hardrada, who claimed the kingdom through a treaty made with Harthacnut. In 1064 Harold fell into William's hands while on a voyage, and according to Norman sources swore an oath recognising William's claim to the English throne.

In 1065 Northumbria flared into revolt against the rule of Harold's brother Tostig. At Oxford Edward and Harold negotiated with the angry northern thegns. They were forced to agree to their demands for the removal of Tostig, and the creation of Morcar, brother of Edwin of Mercia, as earl. Ten weeks after this, on 5th January 1066, Edward died. He had been too ill to attend the consecration of his abbey some days previously on 28th December. The day after Edward's death Harold was consecrated King in the new abbey. Dangers threatened from all sides. In his nine-month reign Harold looked capable of combating them. But a chance arrow at Hastings later in the year put an end to his career. Were it not for this arrow the leopards of the house of Godwine, not the lions of William of Normandy, might today be on the flag of England.

Harold taking leave of King Edward before setting out for Normandy (picture based on the Bayeux Tapestry)

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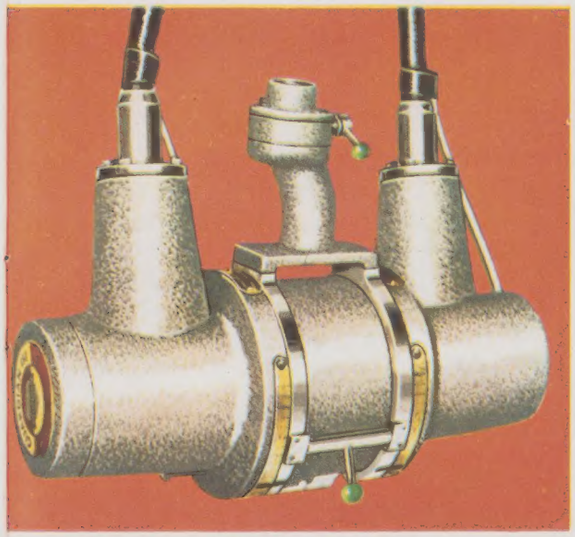


A modern X-ray tube

operation depended on the small quantity of air which was intentionally left in the tubes when they were evacuated. As in the Hittorf tube, each gas tube contained an anode and a cathode, but, in addition, there was a third component known as an *anticathode*, which was placed immediately opposite the cathode so that all the cathode rays impinged directly on it instead of on the wall of the tube. It was, in fact, the X-ray source. As such it protected the tube walls from the damaging effects of cathode-ray bombardment.

Although these early gas tubes worked, they were never very satisfactory for they deteriorated rapidly with use. Furthermore, the intensity of the X-ray beams which they produced was so low that inconveniently long exposures were needed to produce a good X-ray picture, or *radiograph*. In 1913 a great advance was made when W. D. Coolidge invented the *hot cathode tube*. In this the cathode was a spiral wire heated to incandescence by a small electric current as in an electric-light bulb. As well as carrying the heating current, however, the spiral was also raised to a high negative potential. As a consequence the electrons which it produced by reason of its high temperature passed as a stream of cathode rays to the positively charged anticathode at the other end of the tube. On hitting the anticathode they caused the emission of X-rays just as they did in the gas tube. The great advantage of the hot cathode tube was that it had a much longer working life, and its output of X-rays could be controlled by adjustments made to the heating element current and to the potential difference between the cathode and the anticathode.

The linear accelerator

In the 50 years which have passed since the first Coolidge tube was made there have been many developments which have increased its power, its safety, and its efficiency. Consequently it has remained to this day the most commonly used source of X-rays for almost all purposes. The size and cost of an X-ray tube and the apparatus required to supply it with the large potential difference needed to make it operate, however, put a practical limit on the power output which can reasonably be obtained from this type of equipment. Consequently, for a number of very special purposes other X-ray-producing devices have been invented. One such machine is called the *travelling wave linear accelerator*. In it a beam of electrons from an *electron gun* is directed down a tube through which a radio wave is passing in the same direction. The relatively slow-moving electrons of the beam are 'caught' on the waves and so accelerated that they impinge on the anode at the other end of the tube at enormous speed. The X-rays produced as a result of these terrific collisions have very great penetrating power.

Gamma rays

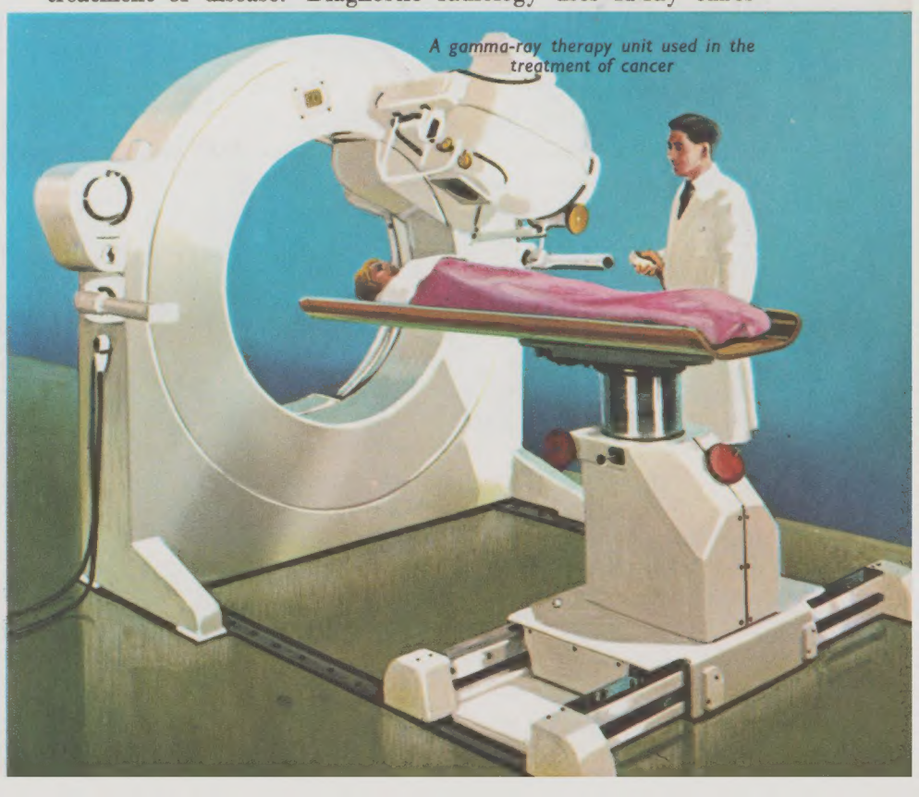
In the year following the discovery of X-rays by Wilhelm Röntgen a Frenchman, Antoine Henri Becquerel (1851–1908), discovered a very similar radiation emanating from uranium ore. Marie and Pierre Curie studied this phenomenon with great care, and in 1898 they discovered the radioactive element *radium*. The penetrating rays which the radium emitted they called *gamma rays* (to distinguish them from other rays called alpha and beta rays), and subsequent research showed that the gamma rays were, in fact, a form of X-ray of high energy.

When the nuclear pile was invented and, after the Second World War, used for peaceful purposes, a new source of gamma rays became available. The isotope of the metal cobalt, known as cobalt 60, was for the first time produced in commercial quantities. The energy of the gamma radiation emanating from this isotope was far greater than that available from any X-ray apparatus. Cobalt 60, therefore, has been adopted as an alternative source of radiation, and it is used particularly when rays with the greatest possible penetration are required. Both X-rays and gamma rays are electromagnetic waves of extremely short wave-length and very high frequency.

The uses of X-rays

Most people's experience of X-rays is associated with the diagnosis of illness, and thus we come to think of X-rays as a purely medical technique. This is far from the truth, as radiation has many applications which have nothing to do with medicine.

In hospitals X-rays are used both for the diagnosis and the treatment of disease. Diagnostic radiology uses X-ray tubes



A gamma-ray therapy unit used in the treatment of cancer

Cover page: Old and new. Above is one of the earliest X-rays, taken in 1895. Below is a travelling wave linear accelerator, one of the modern devices for increasing the penetrating power of X-rays.

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X-ray picture of a human knee

of relatively low power to project a beam of X-rays through a diseased or injured part of the body on to a large sheet of special sensitive photographic film. After development of the film the shadow cast on it is examined for any signs of abnormality.

In the making of a radiograph it is not the X-rays themselves which are used to make the record on the X-ray film but the fluorescence of two 'screens' of calcium tungstate, one of which is pressed to each side of the X-ray film as it lies in a protective *cassette*. The use of *intensifying screens* of this type makes it possible for the radiographer to reduce the exposure to about one-eighth of the time which would be necessary without them, thus saving the life of the tube and reducing the patient's exposure to radiation.

Because X-rays pass very readily through tissues of low density it is, unfortunately, not possible to investigate every organ in the body. Bone and dentine are the most easily seen as they are the densest of the tissues and cast the deepest shadows. But some other organs such as the stomach, the intestines, the gall bladder, and the pelvis of the kidney are less dense and therefore much more difficult to see. This has led to the development of *contrast media*. These are substances which are particularly opaque to X-rays and can be used to fill the various hollow organs of the body to provide an outline of their shapes. Barium sulphate, used to outline the stomach and the intestines, has merely to be swallowed, but the contrast media used to outline the gall bladder and the kidneys have to be given by injection. They are then secreted into the hollow organs where they can be observed on the X-ray picture.

X-ray therapy

In medical treatment X-rays are used mainly, though not exclusively, in the treatment of cancer. This technique is known as *radiotherapy*, and its object is to bombard the cancer with a stream of X-rays of such penetrative power that the cancer cells are destroyed and the growth of the tumour arrested.

In the early days of radiotherapy the gamma rays emanating from radium were chiefly used. These rays had far greater penetrating power than the rays from early low-power X-ray tubes and thus were far more effective. Usually the radium was filled into little 'needles' which were inserted directly into the cancer. With the development of the hot cathode tube, however, it became possible to produce X-rays of much greater power, and the use of radium steadily decreased. At present X-rays from conventional tubes are still the chief source of radiation used in radiotherapy. However, in cases of deep-seated tumours where rays of very great penetrative power are needed, much use is made of the X-rays from the travelling wave linear accelerator and gamma rays from cobalt 60.

A side view of a human neck as it appears on an X-ray plate

X-ray of a stomach and duodenum

Unfortunately, the dose of X-rays needed to treat a cancer effectively sometimes results in a painful and enduring inflammation, or even burning, of the area of skin through which the rays must pass as they enter and leave the body. In order to avoid, or at least to reduce, this danger many X-ray machines are arranged to swing or rotate around the patient so that, while the rays are always directed to the cancer, the continuous movement of the tube ensures that no area of skin receives a dose of X-rays larger than it can withstand.

X-rays in industry

The industrial uses of X-rays and gamma rays are very interesting and varied. At one time almost all industrial radiography was done with X-ray equipment, but with the ready availability and relative cheapness of cobalt 60 this isotope has found many new applications. It has the advantage of being its own source of gamma rays and thus needs no expensive electrical equipment to produce a stream of electrons. Furthermore, it produces rays with very considerable penetrative powers.

X-rays find their greatest usefulness in the metallurgical industries where inspectors use them to examine flaws in castings and to test the effectiveness of welds. X-radiation is also used to examine hand grenades, and the barrels of large guns. Among its other uses are: the inspection of concrete, standing trees, foodstuffs, and the examination of tubes, cans, and hydraulic systems. X-rays are also used to trace wires and pipes in old houses and gold in quartz. They have even been used by customs officers to search for contraband.